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〔資　料〕

The Present Problems of Suspended Particulate Matter (SPM) in Vietnam

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Abstract

To evaluate the influence that big cities in Southeast Asia give to earth environment and to make this information available to the public, in our laboratory, in the form of a database, I have performed environmental researches in several large Southeast Asian cities. This paper reports on the measurement results for SPM (suspended particulate matter) in Hanoi and Ho Chi Ming City in February, 2007. In Vietnam, the public measurement of air pollution can finally be initiated; this was previously impossible as the measured values were not released. The author carried out the measurements using a laser dust monitor, analyzed with the public meteorological data and drew contour maps according to the SPM concentration data. If the method explained in this report is used, without large-scale expensive equipment, it is possible for us to instantly get visual information on air contaminant distribution in cities.

Key words: SPM (浮遊粒子状物質), contour map (コンターマップ), Southeast Asia (東南アジア), laser dust monitor (デジタル粉塵計)

1. Introduction

With regard to global environmental preservation, attention should be focused on preserving the environment of large Southeast Asian cities that have experienced remarkable industry and population growth. Suspended particulate matter (SPM) is one of the air contaminants with the most detrimental effects on human health. However, there are no available quantitative measurements of air pollutants, particularly SPM, over wide areas in Asia. The same levels of SPM have been reported in all prefectures in Japan.

SPM is a type of aerosol with a maximum diameter of 10 micrometers. It includes the exhaust from internal combustion engines, the products of reactions between hydrocarbons and ozone, and natural aerosols. Exhaust gases released and photochemical reactions occurring in regional economic zones, and natural aerosols have become an international problem.

In Japan, a study has reported that exhaust particles from the traffic environment that are termed diesel exhaust particles (DEP) constitute 47.7% of SPM [1]. I am particularly concerned about the relationship between DEP and health effects such as carcinogenicity, bronchial asthma, and hay fever[2]. The Acid Deposition Monitoring Network in East Asia (EANET) carries out acid rain measurements in each East Asian country by a common method[3]. Moreover, the Asian Network of Major Cities 21 Joint Project, as a follow-up the forum, held Working Level Meeting on the Joint Project "Asian Cities Network for Controlling Vehicle Emissions", and measures against exhaust gases of the car were achieved[4].

In this laboratory, I have simulated the SPM levels in inhabited areas in cities. I have also attempted an international comparison of SPM levels taking advantage of existing measurement techniques, and a

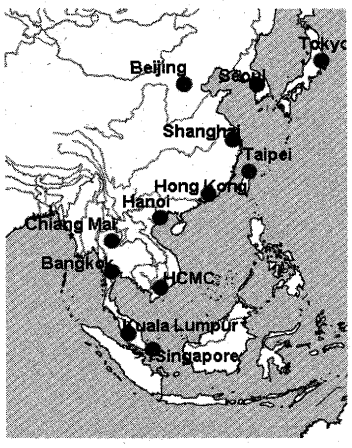


Fig. 1 Asian cities visited for investigation

simple SPM measurement has been carried out in Shanghai, Hong Kong, Singapore, Kuala Lumpur, Bangkok, Chiang Mai, Taipei, Seoul, Hanoi, Ho Chi Minh City, and Beijing [5]. These cities are shown in Fig. 1. In this study, in order to enable residents of large Asian cities to understand the prevailing air pollution situation, pollution measurements have been carried out in Hanoi and Ho Chi Minh City, which are cities with a high population density, with the visualization of SPM concentration distribution.

2. Investigation and analysis method

Time: February 10 (Sat.)-15 (Thu.), 2007.
Participants: Eiko Nakayama (Showa Women's University), Junko Kambe (Daito Bunka University) and Yumie Maeda (a student of Showa Women's University).

Local cooperators: Do Thi Thu Van (Hanoi: Vietnam Building Research Institute) and Nguyen Thi Bich Ngoc (Ho Chi Minh City: Ho Chi Minh City Construction University). Individual affiliations are during the time of investigation.

Measurement place: Pollution at the crossings of major thoroughfares in 51 places in Hanoi and 60 places in Ho Chi Minh City were measured from a car. In addition to SPM measurements, the wind direction, wind speed, temperature, and relative humidity were measured simultaneously, and the measurement sites were photographed.

Measurement apparatus: Laser dust monitors LD-1 and LD-3 K (Sibata Science Company) were used to measure SPM, and the amount of particulates detected in 1 min was counted; this amount was converted into SPM concentration. A digital temperature and relative humidity anemometer, i.e., FUSO-8918 (Fuso Science Product Company), was used to measure wind speed, temperature, and relative humidity. Photographs were taken using an EOS digital X (Canon) camera with an EF 100-mm F 2.8 macroscopic USM lens. The images were saved in RAW format for analysis.

Meteorological data: The temperature, humidity, atmospheric pressure, visibility, wind direction, wind speed, precipitation, and weather situation were downloaded from the Weather Underground website at 1 hour intervals [6]. In addition, I received weather charts of the study days from the Australia Meteorological Service [7] for analysis.

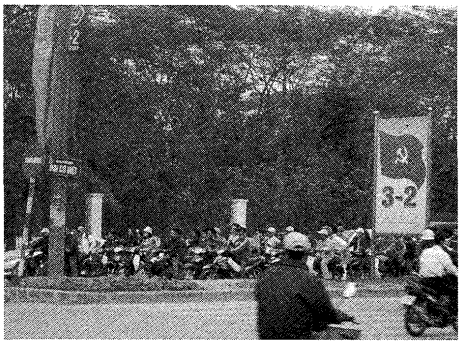
Visualization of SPM concentration: In order to visualize the distribution of the SPM concentration, contour maps were created using Contour Map 97. xla ver. 1.0 [8]. I was permitted use of this software without charge for my research.

Analysis of photo images: The images were saved in the RAW format using EOS, and RGB analysis of the images was conducted using the image-analysis soft "daisy collage 10" by Ichikawa Soft Laboratory.

3. Results and Discussions

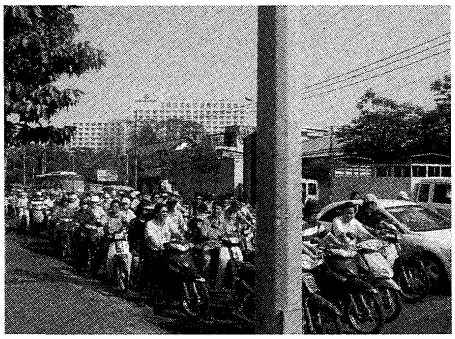
The results of the measurements in Hanoi and Ho Chi Minh City performed from February 10 through 15, 2007 are shown in Tables 1 and 2. The environment at the measurement site is shown in photographs 1 and 2. In Vietnam, as shown in the photographs, motorcycle riders generally drive without helmets and sometimes with several family members or a similar large load, which is not observed in Japan. Moreover, many motorcycles were

a)

b)


Photograph 1. Measurement sites in Hanoi
a) Quan Ba Dinh District, the crossing of Pho Ngyen Thai Hoc and Duan Le Duan
b) Quan Hai Ba Trung District, the crossing of Duang Bai Co Viet and Duang Giai Phong

a)



b)

c)

Photograph 2. Measurement sites in Ho Chi Minh City

a) The crossing of Tran Hung Dao and Dai Lo Nguyen Thai Hoc, District 1
b) The crossing of Nguyen Dinh Chieu and Nguyen Thuong Hien, District 3
c) The crossing of Ton Duc Thang and Le Thanh Ton, District 1

Table 1. Results of the measurements in Hanoi

Date	Weather	Temp.; ℃	RH; %	Wind Direction	Wind Velocity; m/s	Time (local)	Area	Measurement Point West-East	Measurement Point North-South	SPM conc.; $\mu g/m^3$
070210						20:20	Quan Hoan Kiem	Hoa Binh Hotel	3 F	167.0
070210	cloudy	23.8	69.5	C		20:27	Quan Hoan Kiem	Hoa Binh Hotel		187.5
		22.5	72.0	C		20:34	Quan Hoan Kiem	Pho Ly Thoung	Pho Hang Bai	170.0
		23.1	72.8	C		20:40	Quan Hoan Kiem	Pho Hai Ba Trung	Pho Hang Bai	183.0
		22.6	71.6	C		20:48	Quan Hoan Kiem	Pho Hai Ba Trung	Pho Ngo Quyen	176.0
		22.5	72.2	C		20:55	Quan Hoan Kiem	Pho Ly Thoung	Pho Ngo Quyen	143.0
070211		23.6	70.5			8:15	Quan Hoan Kiem	Hoa Binh Hotel	Robby	233.0
	cloudy	22.9	62.7	C		8:21	Quan Hoan Kiem	Hoa Binh Hotel		240.0
		23.1	69.5	C		8:30	Quan Hoan Kiem	Pho Hai Ba Trung	Pho Hang Bai	258.0
		22.6	67.9	C		8:34	Quan Hoan Kiem	Pho Hai Ba Trung	Pho Hang Bai	269.0
		22.5	72.9	C		8:47	Quan Hoan Kiem	Pho Le Lai	Pho Dinh Tien Hoang	243.5
	mostly sunny	22.5	70.8	C		8:54	Quan Hoan Kiem	Pho Lo Su	Pho Dinh Tien Hoang	261.5
		23.7	68.6	C		9:16	Quan Hoan Kiem	Hang Gai	Hang Dao	251.5
		24.8	60.2	C		10:15	Quan Hoan Kiem	Pho Ly Thung Kiet	Pho Le Thanh Tong	284.5
		25.0	63.7	C		10:30	Quan Hoan Kiem	Pho Ly Thung Kiet	Pho Le Thanh Tong	258.0
		25.7	63.0	C		11:03	Quan Thanh Xuan	Nga Tu So	Pho Tay Son	239.5
	partly cloudy	25.8	58.2	C		11:10	Quan Don Da	Duong Chua Boc	Pho Nguyen Luong Ban	266.5
		25.6	57.5	C		11:34	Quan Don Da	Pho Thai Ha	Pho Lang Ha	230.5
		24.3	57.3	C		11:50	Quan Don Da	Huynh Thuc Khang	Pho Nguyen Chi Thanh	211.5
		25.3	57.8	C		12:04	Quan Don Da	Duong La Thanh	Pho Nguyen Chi Thanh	217.5
		26.7	51.4	SSW	0.6	13:43	Quan Don Da	Duong La Thanh	Pho Giang Vo	185.0
		26.2	50.5	C		13:55	Quan Don Da	Duong La Thanh	Tong Duc Thang	175.0
		25.5	53.8	SWW	3.3	14:18	Quan Tay Ho	Duong Yen Phu	Duong Thanh Nien	162.0
				SE	1.1	14:22	Quan Tay Ho	Duong Yen Phu	Duong Thanh Nien	183.0
		23.5	59.9	C		14:30	Quan Tay Ho		Duong Thanh Nien	164.0
				C		14:40	Quan Tay Ho			153.0
		25.8	54.7	C		14:56	Quan Tay Ho	Duong Thuy Khue	Duong Thanh Nien	157.5
		27.3	51.4	C		15:15	Quan Tay Ho	Duong Thuy Khue	Duong Buoi	167.5
		24.9	54.8	C		16:10	Quan Tay Ho	Duong Thuy Khue	Duong Hoang Hoa Tham	163.0
		25.2	53.5	C		16:20	Quan Ba Dinh	Pho Kim Ma	Pho Giagn Vo	151.0
		25.2	54.1	C		16:33	Quan Ba Dinh	Pho Ngyen Thai Hoc	Duan Le Duan	156.5
		24.4	54.1	C		16:42	Quan Hoan Kiem	Hoa Binh Hotel		161.0
070212	cloudy	20.7	82.1	C		8:10	Quan Hoan Kiem	Hoa Binh Hotel		230.0
		22.2	79.1	C		8:19	Quan Hoan Kiem	Pho Ly Thung Kiet	Pho Le Thanh Tong	277.5
		22.6	76.8	C		8:38	Quan Hoan Kiem	Pho Ly Thung Kiet	Pho Le Thanh Tong	297.5
		23.5	75.6	C		9:00	Quan Hoan Kiem	Pho Ly Thung Kiet	Pho Le Thanh Tong	279.0
		22.8	76.7	C		9:10	Quan Hoan Kiem	Hoa Binh Hotel		238.0
	cloudy	23.8	74.0	C		9:50	Quan Long Bien	Pho Nguyen Van Cu		215.5
		24.6	65.3	C		10:06	Quan Long Bien	Pho Nguyen Van Cu		147.0
		24.0	68.8	S	1.2	10:33	Quan Hai Ba Trung	Pho Minh Khai	Pho Kim Nguu	110.5
		24.6	65.0	C		10:45	Quan Hai Ba Trung	Pho Minh Khai	Pho Bach Mai	135.5
		25.1	63.4	C		11:10	Quan Dong Da	Duong Trung Chinh	Duang Giai Phong	138.0
		24.7	60.0	S	0.8	11:27	Quan Hai Ba Trung	Duang Bai Co Viet	Duang Giai Phong	81.0
		23.6	69.5	S	0.9	11:44	Quan Hai Ba Trung	Pho Tran Khat Chan	Pho Hue Hue	70.0
		25.7	62.5	C		12:00	Quan Hai Ba Trung	Pho Tran Khat Chan	Pho Kim Nguu	90.0
		26.6	67.1	C		12:32	Quan Hoan Kiem	Pho Hai Ba Trung	Duong Le Duan	157.0
		25.7	65.0	C		14:17	Quan Hoan Kiem	Han Thuyen	Phan Chu Trainh	93.0
		25.7	63.2	W	1.1	14:37	Quan Hoan Kiem	Pho Hang Khoai	Tran Nhat Duat	80.5
		23.7	68.7	SW	2.8	15:34	Quan Hoan Kiem	Tran Tien	Le Thanh Tong b	112.0
	cloudy	23.8	70.9	C		15:47	Quan Hoan Kiem	Pho Ly Thung Kiet	Pho Le Thanh Tong	102.0
		24.5	66.2	C		16:06	Quan Hoan Kiem	Hoa Binh Hotel		81.0

C: Calm

Table 2. Results of the measurements in Ho Chi Minh City

Date	Weather	Temp.; ℃	RH; %	Wind Direction	Wind Velocity; m/s	Time (local)	Area	Measurement Point West-East	Measurement Point North-South	SPM conc.; $\mu g/m^3$
070213		27.3	68.8	C		18:30	District 1	Bong Sen Hotel		48.0
070214		26.7	73.0	C		8:15	District 1	Bong Sen Hotel		83.0
		25.8	69.7	C		8:25	District 1	Bong Sen Hotel		78.0
		27.0	66.3	C		8:53	District 1	Duong Pham Ngu Lao	Cong Quynh	81.5
		28.5	63.2	C		9:04	District 1	Nguyen Trai	Dai Lo Nguyen	75.0
		29.3	72.3	C		9:13	District 1	Tran Hung Dao	Dai Lo Nguyen Thai Hoc	84.5
	mostly sunny	29.7	58.2	C		9:25	District 1	Le Lai	Calmette	60.5
		30.5	54.0	C		9:50	District 4	Hoang Dieu	Nguyen Tat Thanh	43.5
		32.2	50.2	S	0.9	10:05	District 7	Tran Van Khanh	Duong Huynh Tan Pha	46.0
		31.2	48.6	C		10:40	Binh Thanh District	NG.N.Phuong	Xo Viet Nghe	43.0
		31.9	48.7	C		10:55	Binh Thanh District	Duong Dien Bien Phu	Xo Viet Nghe	64.0
		33.4	44.3	S	1.1	11:05	Binh Thanh District	Duong Bach Dang	Dinh Bo Linh	78.0
	sunny	32.1	46.3	C		11:15	Binh Thanh District	Duang Bach Dang	Bui Huu Nghia	41.0
		34.2	42.8	S	1.2	11:45	District 3	Duong Dien Bien Phu	Duong Psteur	48.5
		32.0	54.1	C		13:15	District 3	Duong Dien Bien Phu	Trung Dinh	46.0
		34.2	45.8	C		13:25	District 1	Vo Thi Sau	Dinh Tien Hoang	43.0
		34.3	43.0	C		13:40	District 1	Hai Ba Trung	NG. Huu Cau	32.0
		34.4	44.4	C		13:47	Phu Nhuan District	Phan Dang Luu	Duong Phan Dinh Phung	32.0
		34.7	43.9	SW	1.2	14:00	Tan Binh District	Hoang Van Thu	Tran Q.Hoan	40.5
		33.0	42.6	S	1.1	14:10	Phu Nhan District	Nguyen Van Troi	Tran Huy Lieu	47.0
		34.1	43.3	C		14:25	Phu Nhan District	Le Van Sl	Tran Quang Dieu	58.0
		33.2	46.6	C		14:35	District 10	Duong Cash Mang Thang Tam	Dai Lo 3 Thang 2	44.7
		31.9	46.4	C		15:37	District 3	Nguyen Dinh Chieu	Nguyen Thuong Hien	38.3
		31.3	47.4	SW	1.6	15:45	District 10	Duong Dien Bien Phu	Le Hong Phong	29.5
		32.3	64.6	C		15:50	District 5	Dai Lo Ngo Gia Tu	Nguyen Tri Phuong	33.5
		32.6	44.4	C		16:03	District 5	Dai Lo An Duong Vuong	Dai Lo Tran Phu	37.0
		30.8	52.5	C		16:12	District 1	Nguyen Trai	Dai Lo Nguyen Van Cu	30.5
		32.5	46.9	SE	1.3	16:18	District 1	Tran Hang Dao	Dai Lo Nguyen Van Cu	26.0
		32.6	46.1	C		16:28	District 1	Ly Thai To	Dai Lo Nguyen Van Cu	29.0
		29.5	56.9	C		16:50	District 1	Bong Sen Hotel		22.5
070215		15.6	78.1	C		7:55	District 1	CLARINS 前		55.0
		26.6	79.6	E	2.3	8:00	District 1	Bong Sen Hotel		71.5
		26.3	76.1	C		8:13	District 1	CLARINS 前		69.5
		25.8	75.0	E	0.5	8:20	District 1	Bong Sen Hotel		57.5
	mostly sunny	31.0	55.3	C		9:05	District 5	Dai Lo Tran Hung Dao	Nguyen Tri Phuong	65.5
		29.9	58.8	C		9:17	District 5	Dai Lo Hungt Vuong	Chau Van Liem	84.5
		30.2	56.3	C		9:27	District 5	Hai Thuong Lan Ong	Chau Van Liem	51.5
		32.3	72.3	C		9:37	District 5	Le Quang Sung	Ngyen Huu Than	91.0
		33.3	46.5	E	0.7	9:45	District 6	Dai Lo Thap Muoi	Cho Binh Tay	67.7
		31.2	50.2	E	0.7	10:05	District 6	Dai Lo Thap Muoi	Minh Phung	32.5
		31.6	50.2	C		10:17	District 11	Dai Lo 3 Thang 2	Minh Phung	53.5
		31.6	50.2	C		10:22	District 11	Dai Lo 3 Thang 2	Le Dai Hanh	52.0
		32.5	46.6	C		10:32?	District 11	Lac Long Quan	Duong Au Co	67.3
		33.2	47.0	C		11:00	Tan Binh District	Lac Long Quan	Ly Thuong Kiet	43.0
		32.2	52.8	C		12:55	District 1	Nguyen Du	Ky Khoi	30.0
		33.7	45.9	S	0.4	13:13	District 1	Ton Duc Thang	Le Thanh Ton	27.0
		32.5	44.6	S	1.1	13:20	District 1	Cong Truong Me Linh	Ton Duc Thang	22.5
		34.2	48.2	S	1.9	13:47	District 7	Nguyen Cao Nam	Dai Lo Nguyen Van Linh	16.5
		32.3	46.7	S	1.2	13:57	District 7	Nguyen Duc Canh	Dai Lo Nguyen Van Linh	17.5
		33.2	46.6	S	0.3	14:15	Binh Chanh Country	Duong Pham Hung		51.0
		33.3	43.5	S	2	14:25	District 8	Pham The Hien	Chanh Hung	41.7
		33.1	42.5	S	1.4	14:35	District 5	Dai Lo Tran Hung Dao	Nguyen Tri Phuong	27.5
		34.8	40.7	C		14:42	District 11	Dai Lo 3 Thang 2	Nguyen Tri Phuong	32.5
		35.1	41.0	S	0.4	15:30	District 10	Thanh Thai	To Hien Thanh	38.5
		34.9	39.1	SE	0.5	15:42	District 10	To Hien Thanh	Duonh Cach Mang Thang Tar	38.0
		32.5	43.7	S	0.8	15:45	District 3	Nguyen Phuc Nguyen		19.5
		31.9	47.0	C		16:00	District 3	Duonh Cach Mang Thang Tam	Nguyen Thi Minh Khai	28.0
		31.3	48.4	C		16:12	District 1	Hai Ba Trung	Nguyen Thi Minh Khai	19.0
		30.6	50.9	C		16:37	District 1	CLARINS 前		19.0
		28.9	53.2	S	1.3	16:42	District 1	Bong Sen Hotel		13.5

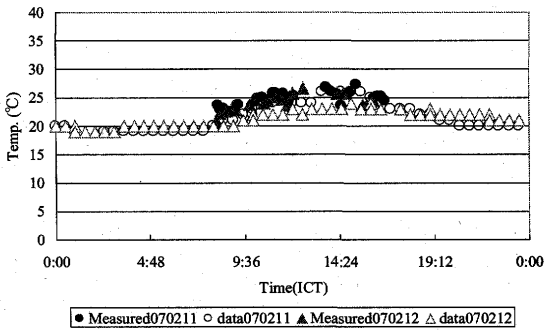
C: Calm

parked on sidewalks and were supervised by guards.

The climatic conditions during the measurement period are expressed using graphs constructed from the data in Tables 1 and 2 and from downloaded meteorological data. The temperature of the measurement sites during the measurement period are shown in Fig. 2. Hanoi did not experience steep increases in daytime temperature due to cloudy skies. In addition, since the measurements were carried out on main roads, the measured temperatures tended to be somewhat higher than the downloaded temperature data values.

The relative humidity of the measurement sites during the measurement period is shown in Fig. 3.

a)



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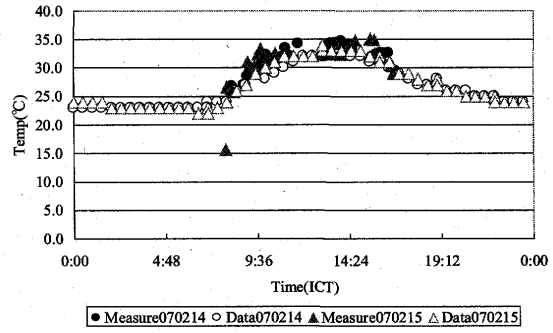


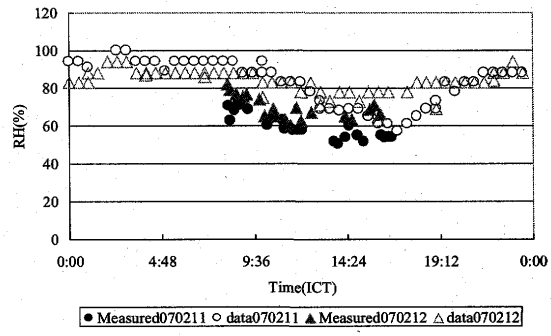
Fig. 2. Temperature at the measurement sites during the measurement period
a) Hanoi, b) Ho Chi Minh City

Since the measured temperatures were slightly higher than the downloaded temperatures, the relative humidity exhibited a slight decrease compared to the downloaded data. In Ho Chi Minh City, due to fine weather conditions, the phenomenon of decreasing relative humidity values with rising morning temperatures was observed; the relative humidity of the measurement sites also exhibited this phenomenon.

The atmospheric pressure change at sea level during the measurement period is shown in Fig. 4. When compared with the weather charts, it was thought that the south wind was probably blowing gently during the measurement period; no weather change was observed, and Ho Chi Minh City experienced high pressure conditions.

The wind direction and wind speed at the measurement sites in Hanoi and Ho Chi Minh City during the measurement period are shown in Fig. 5. The south-southeast direction was observed to be the main direction of wind flow. The influence of the wind created by the car's movement was very strong; therefore, measurement was difficult in these places.

a)



b)

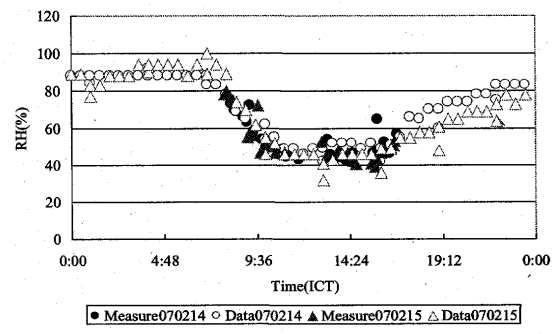
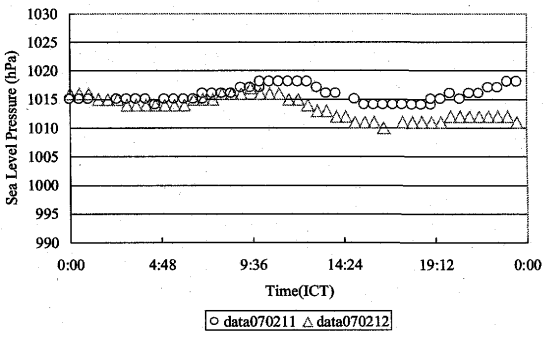


Fig. 3. Relative humidity at the measurement sites during the measurement period
a) Hanoi, b) Ho Chi Minh City

a)



b)

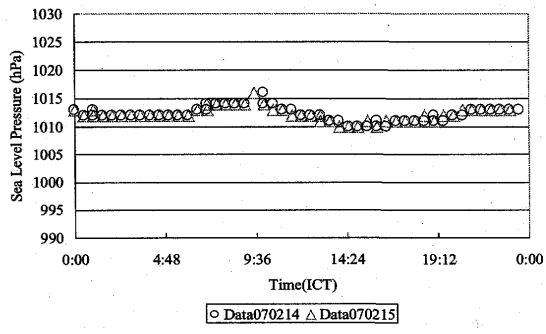


Fig. 4. Atmospheric pressure at sea level during the measurement period
a) Hanoi, b) Ho Chi Minh City

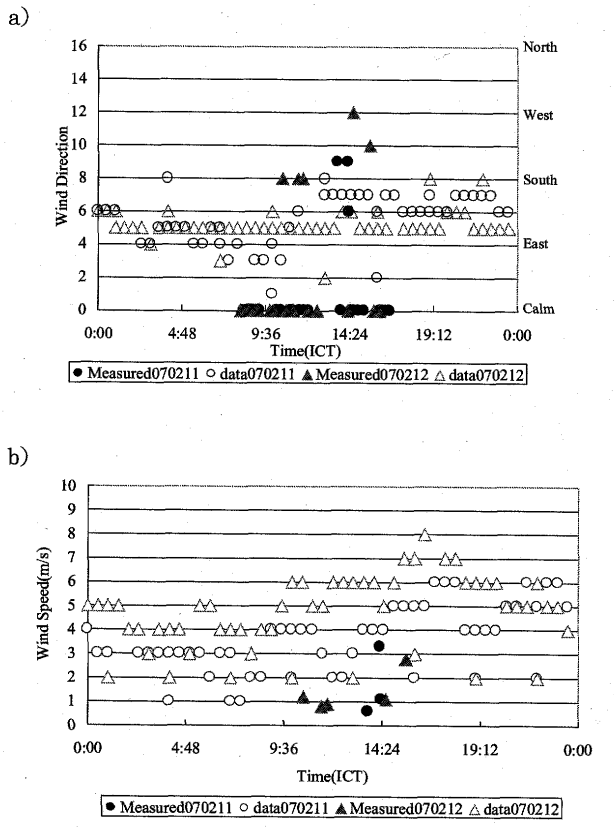


Fig. 5. Wind direction and speed at the measurement sites during the measurement period
a) Wind direction in Hanoi, b) Wind speed in Hanoi c) Wind direction in Ho Chi Minh City, d) Wind speed in Ho Chi Minh City

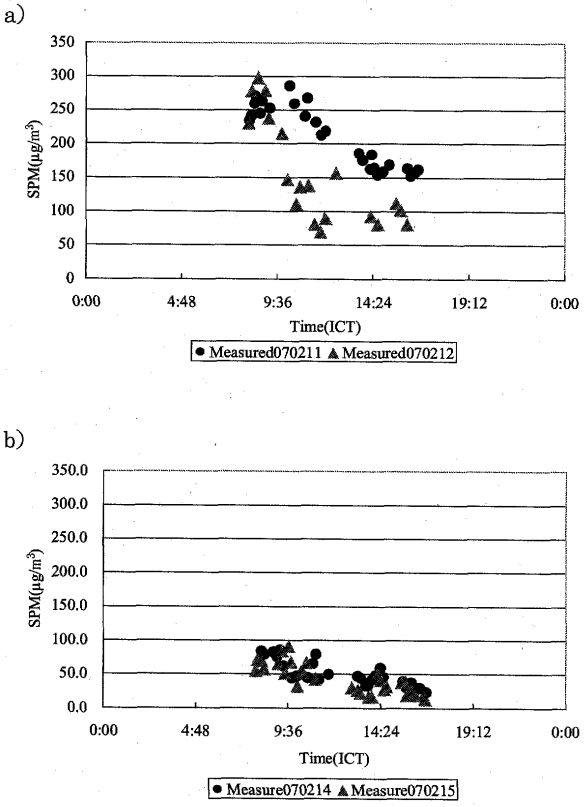


Fig. 6. Change in the SPM concentration over time at the measurement sites
a) Hanoi, b) Ho Chi Minh City

The measurements in a few places were based on south winds. Although the graph of wind speed appears irregular, when converted to Beaufort wind velocities, the wind speed was ranked from force 3 to force 4. Further, the wind speed at the measurement sites is an instantaneous value near the ground in the absence of traffic, and its accurate measurement was not possible.

The change in the SPM concentration over time at the measurement sites is shown in Fig. 6. The SPM concentration decreased during the afternoon in both cities. The following factors are thought to contribute toward the variation in SPM concentration. The relative humidity was very high in the morning and decreased as the day progressed; the soil temperature was rising during the daytime with an ascending current. In Hanoi, exhaust gases released at night collected near the surface of the ground due to an overcast sky. However, no conclusion can be made based on these measurements. It is regrettable that there is no existing data to

Table 3. Environmental Standards of Vietnam[9], WHO and Japan

Pollutant	Vietnam Standard; $\mu g/m^3$	WHO Standard; $\mu g/m^3$	Japan Standard; $\mu g/m^3$	Time Period hours
Particulate Matter	200	150	100	24
Sulfur Dioxide	300	125	40	24
Nitrogen Dioxide	100	150	60	24
Carbon Monoxide	10	10	20	8

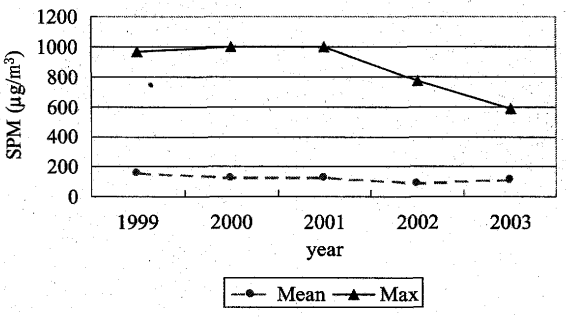


Fig. 7. SPM annual values recorded from 1999 through 2003 in Hanoi[10]

complement these results.

In Hanoi, unlike in Japan, a high concentration of SPM was measured. The environmental standards recommended by the WHO, Vietnam, and Japan are compiled and are shown in Table 3. In Vietnam, air-related environmental standards were fixed in 1995. Related standards include TCVN 5937 (air quality-ambient air quality) and TCVN 6438 (air quality-road vehicles emission). Presently, a system of monitoring appears to be in place. The SPM annual values (mean value and maximum) recorded from 1999 through 2003 in Hanoi [10] are shown in Fig. 7. The SPM values reported are surprising. However, I believe that they have been measured accurately. The visibility during the measurement period is shown in Fig. 8. In Ho Chi Minh City, although the measured value indicates a visibility of 10 km, visibility could be $\geq$ 10 km. The visibility in a range of $\leq$ 10 km with $\geq$ 75% relative humidity was termed "mist." On the other hand, the visibility in Hanoi was almost always $\leq$ 5 km. Although SPM alone does not affect the visibility, it is increasingly regarded as an important index when considering the air environment. Further, visual flights will be impossible if the visibility falls below 5 km[11]. The

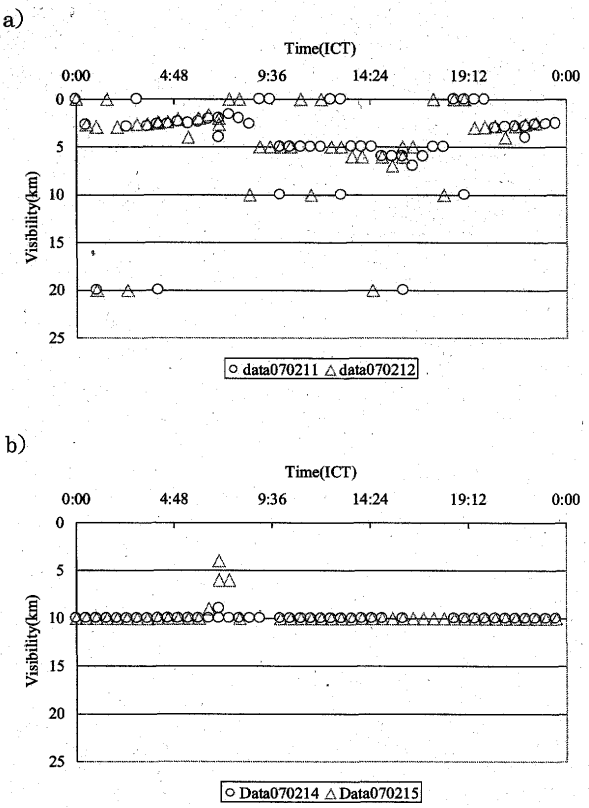


Fig. 8. Visibility during the measurement period
a) Hanoi, b) Ho Chi Minh City

SPM value measured in Hanoi is very high compared to that in Japan, but it should be accepted. It is surprising that Hanoi residents, in particular, do not regard this situation as problematic.

The measurement of SPM was performed for 2 days in each city. Since the measured SPM value decreased toward the evening, the rate of standard deviation was high at 33.6% in Hanoi and 43.6% in Ho Chi Minh City. Since the absolute value of SPM is small in Ho Chi Minh City, it is considered that some changes considerably affect the standard deviation. The contour maps of SPM values obtained from these results are shown in Figs. 9 and 10.

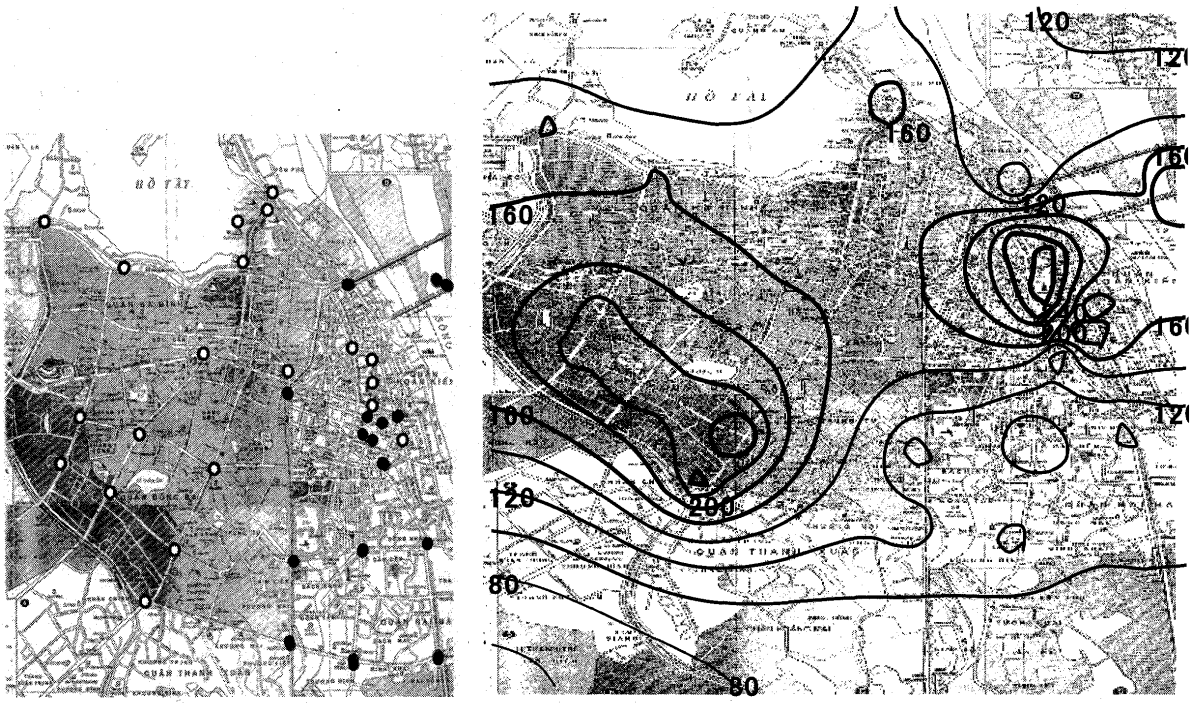


Fig. 9. Measurement points (●: 070211, ○: 070212) and contour map in Hanoi (SPM conc.; $\mu g/m^3$)

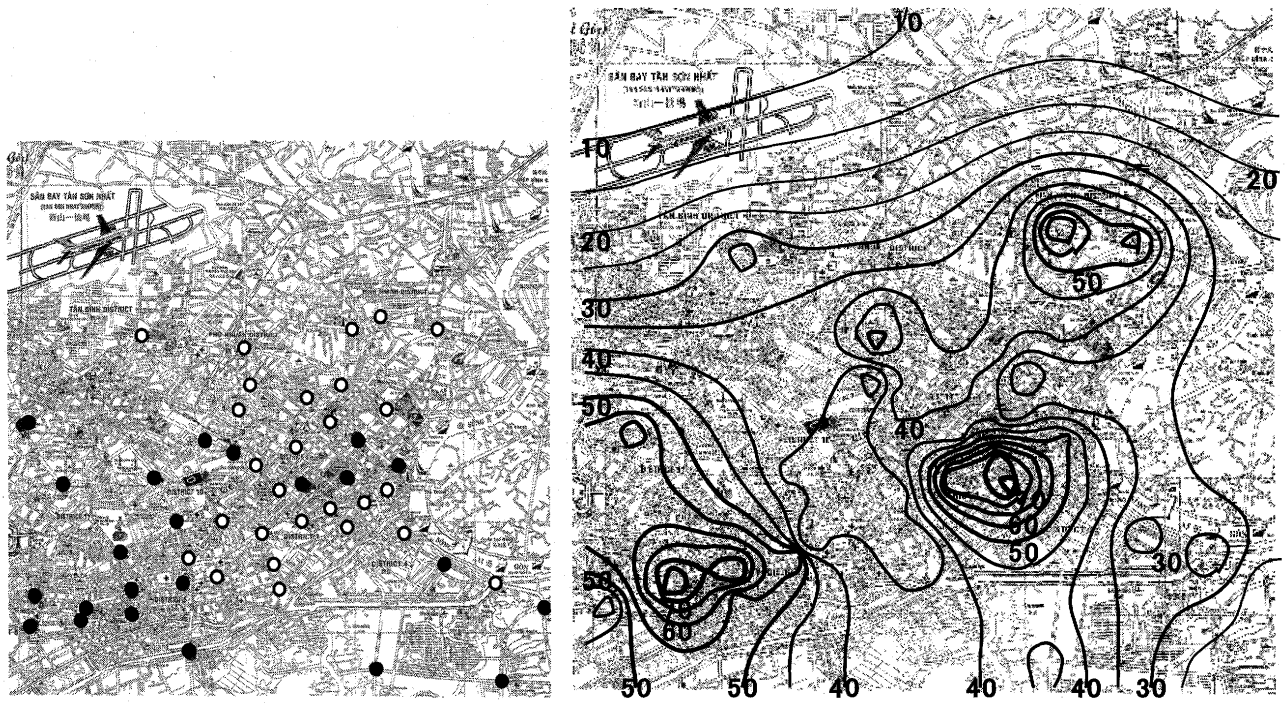


Fig. 10. Measurement points (○: 070214, ●: 070215) and contour map in Ho Chi Minh City (SPM conc.; $\mu g/m^3$)

a)

b)

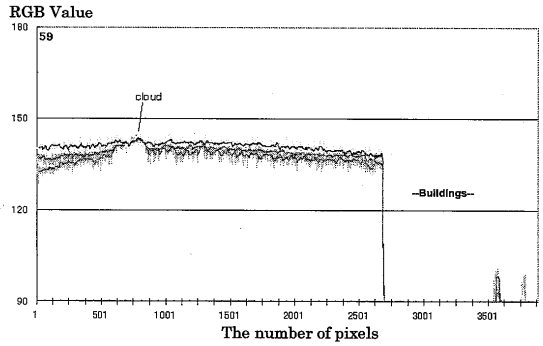
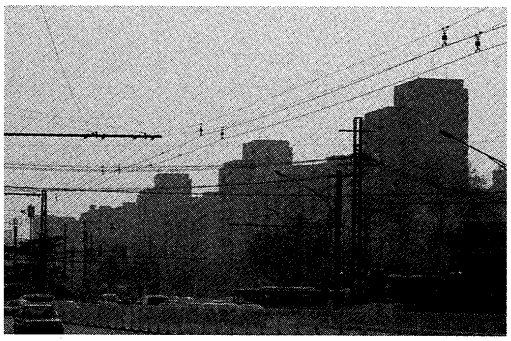


Fig. 11. Image analysis of the sky above Ho Chi Minh City

a) Photograph taken at 13:18 on February 14, 2007.
b) Result, digitalized portion of the sky observed toward the left of the RAW photograph.

a)



b)

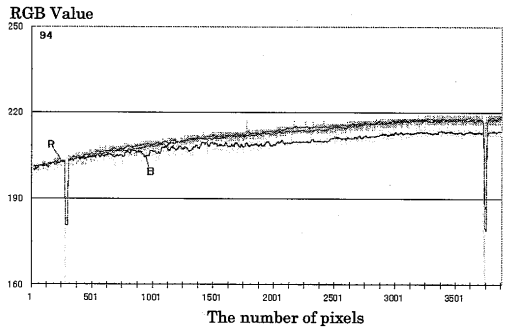


Fig. 12. Image analysis of the sky above Beijing[12,5]

a) Photograph taken at 10:13 on March 12, 2007.
b) Result, digitalized portion of the sky observed toward the left of the RAW photograph.

The measured value of SPM was high in shopping zones that included markets, hotels, and department stores in both Hanoi and Ho Chi Minh City. Moreover, it is observed that the SPM moves toward the north. The sources of SPM in both cities were not from the south. The south wind is one of the reasons for the decrease in the measured value of SPM during the afternoons as shown in the figures.

Finally, the photograph of the sky above Ho Chi Minh City is shown in Fig. 11. RGB analysis was conducted on the portion of the sky observed toward the left on the RAW photograph taken on the afternoon of February 14. This value differed from that observed in the pictures of Ho Chi Minh City with white clouds and blue skies. Then, the photograph of Beijing was shown in Fig. 12[12, 5] for comparison. In Beijing, it is suggested that Mie dispersion might have taken place and the particles of a size comparable to a wavelength were uniformly distributed in the atmosphere.

4. Conclusion

SPM contour maps of inhabited areas were obtained by simple measurements, which is a special feature of this study. The laser digital coarse particulate meter enables simple measurement; further, it is less expensive than the beta ray absorbing method utilized by the automatic instrument currently installed in official SPM measurement offices in each country. Due to its ease of operation, measurements can be made without extensive training. Moreover, it is possible to obtain reproducible data. Since measurements were made at the crossings of different main streets, which occupy the centers of inhabited areas, the data values by themselves are discrete; however, by correlating the values and drawing a contour map, the pollution situation is visualized, and the SPM source can be intuitively determined. That is, to draw a contour map can be said to be one of the important techniques for deducing the SPM source which affects our life.

In Vietnam, the public measurement of air pollution can finally be initiated; this was previously impossible as the measured values were not released

and the downloading of meteorological data was impossible. Exhaust gases from two-wheelers and cars, the production of which has rapidly increased since the 1980s, is mentioned as a primary pollution source. The number of motorcycle owners in large cities has increased by 18% every year from 1993 to 2000. According to the data on fuel consumption, gasoline is used in approximately 75% of cars and motorcycles, while the remaining 25% utilize diesel[13]. Lead from car exhausts was a source of concern in addition to PM; however, this problem was eliminated by the adoption of unleaded gasoline in 2001. Further, the smoke from thermal power plants and factories contain sulfur oxides (SOx) and PM; I am particularly concerned about air pollution in areas in northern Vietnam that utilize coal as the main fuel.

It is becoming apparent that the effects of SPM vary from those of gaseous air pollutants such as NOx and SOx[14]. SPM is an independent quality parameter of air pollutants that should necessarily be measured, and the measurement results of nitrous oxides (NOx) or SOx cannot be substituted for it. Further, the dissemination of information in a form that is clearly understood by residents is desirable.

I currently possess the analyzed SPM data from certain large cities in Asia; I intend to release this information to the public in the form of a database shortly. The research and the international comparison of air pollution data from the viewpoint of suitability for inhabitation are yet to be carried out. I wish to study the air environment in the Asian area and serve as an aid for residents to understand and protect the air environment of the area (inhabited space) that they reside in.

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*The last verified date of Website is September 28, 2007.

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